Large-scale Morphological Changes in the Hapi region on Comet 67P/C-G

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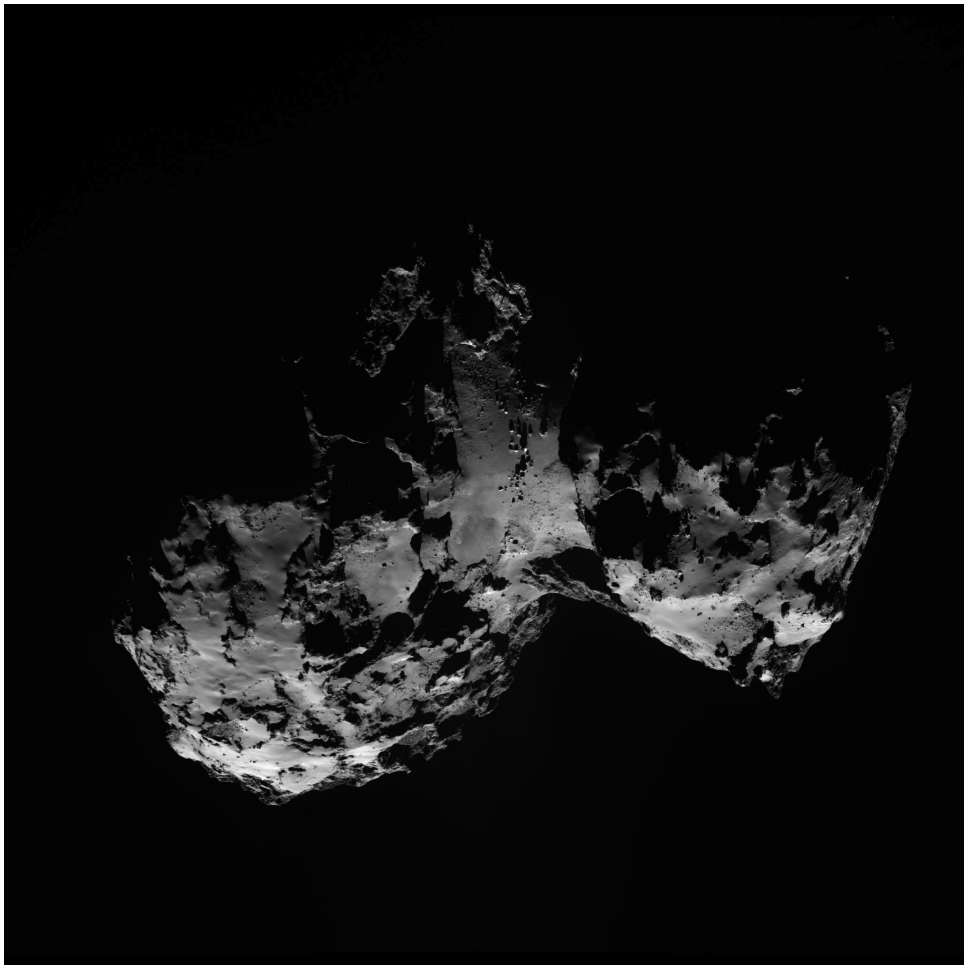
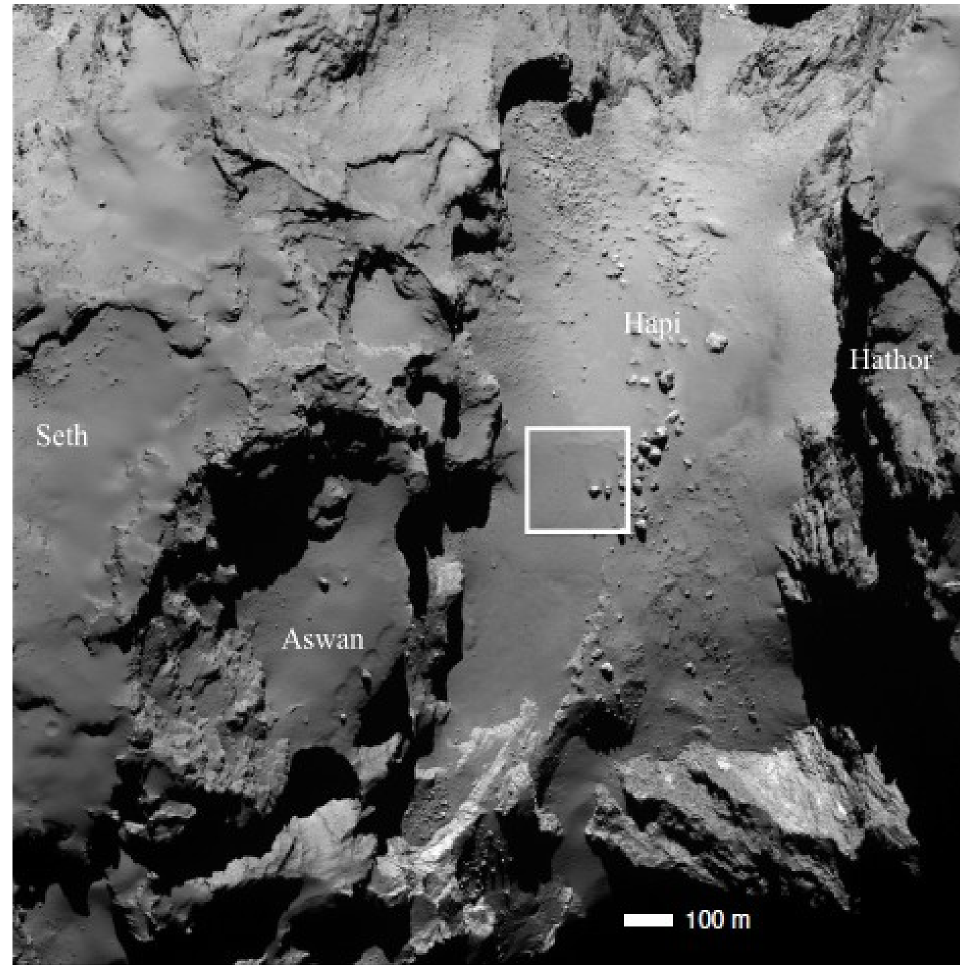
Summary

- Progress report since SWT Toulouse
- OSIRIS detected large-scale changes in the Hapi region
  - Morphology versus time
  - Shape model: local gravity and illumination conditions
  - Spectrophotometry
- MIRO measured nucleus thermal emission at 1.59 mm and 0.53 mm
  - Temperature versus time and depth
  - Thermal inertia, ice abundance, extinction and scattering coefficients
  - Characterize conditions before, during, and after events
  - Compare with similar control regions where no changes were observed

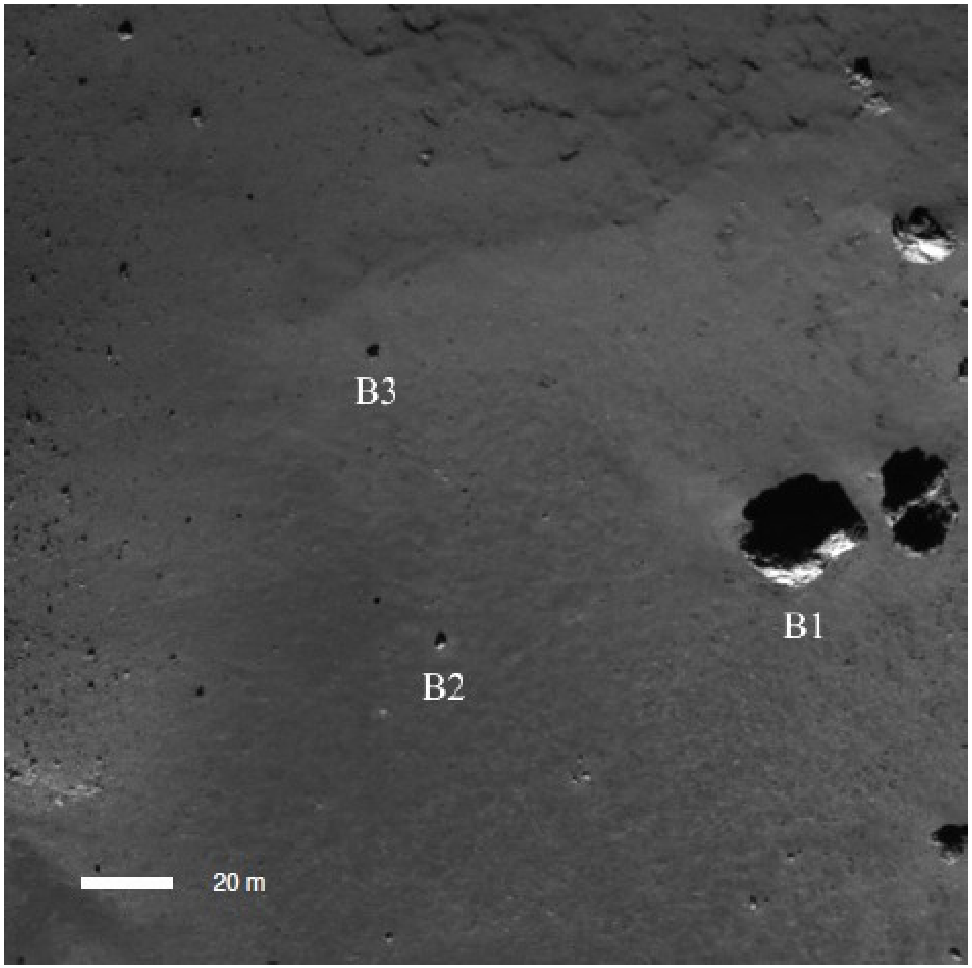
Context



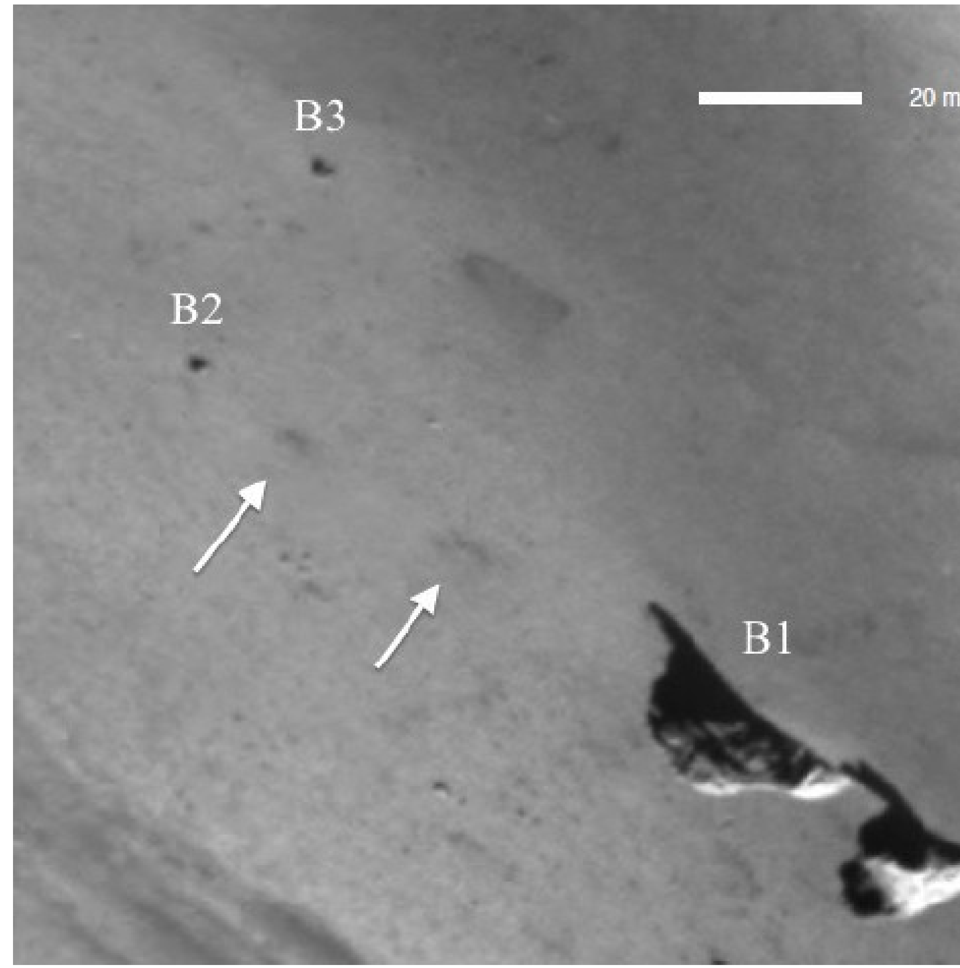


Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2017, in preparation)

A large shallow depression emerges



Dec 10, 2014. NAC 20 km: 0.35 m px^{-1}.
No change since Aug 2014.



Dec 30, 2014. NAC 28 km: 0.49 m px^{-1}.
Two dark spots ~ 5-8m across.

Credit: ESA/Rosetta/MPS for OSIRIS Team
MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2017, in preparation)

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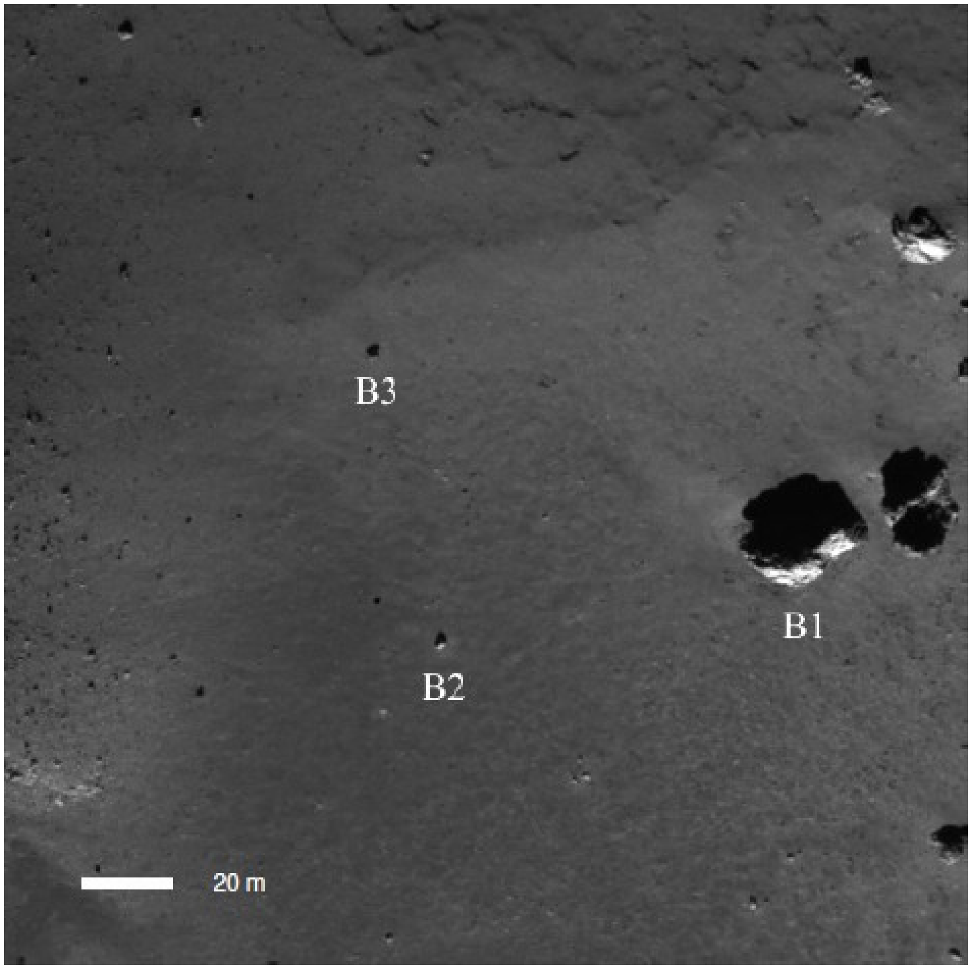

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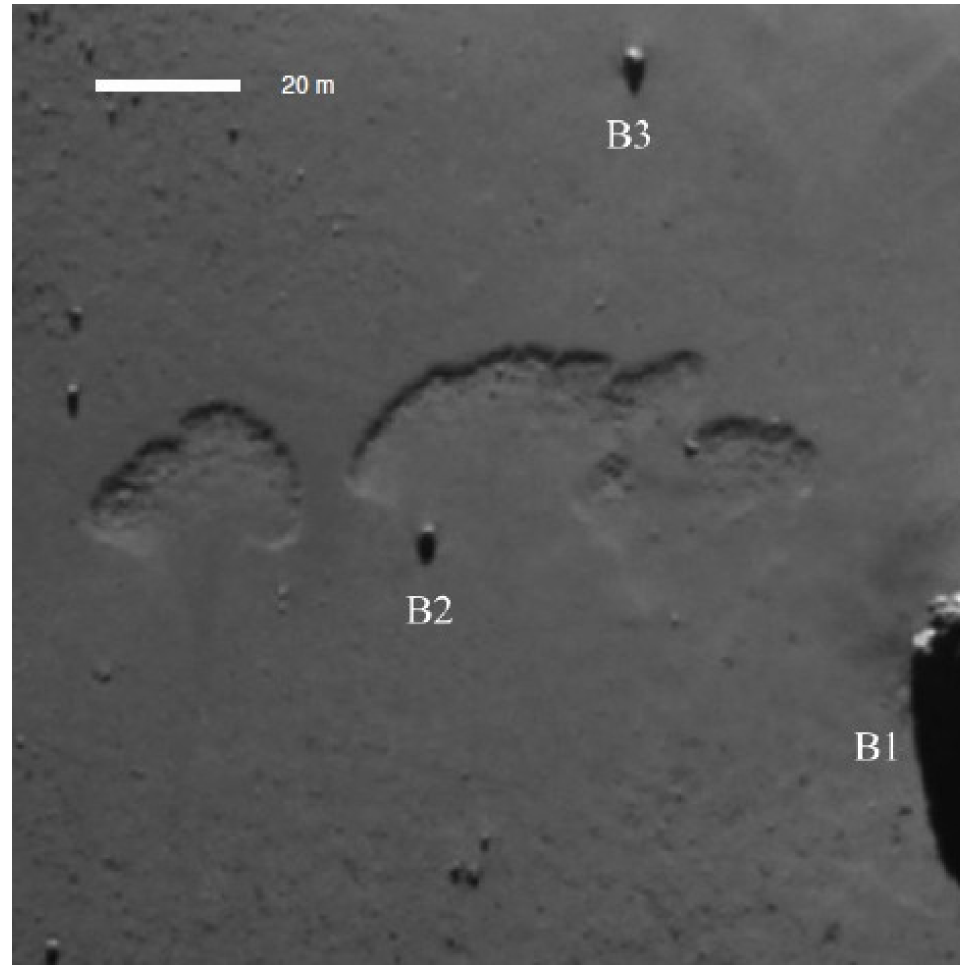
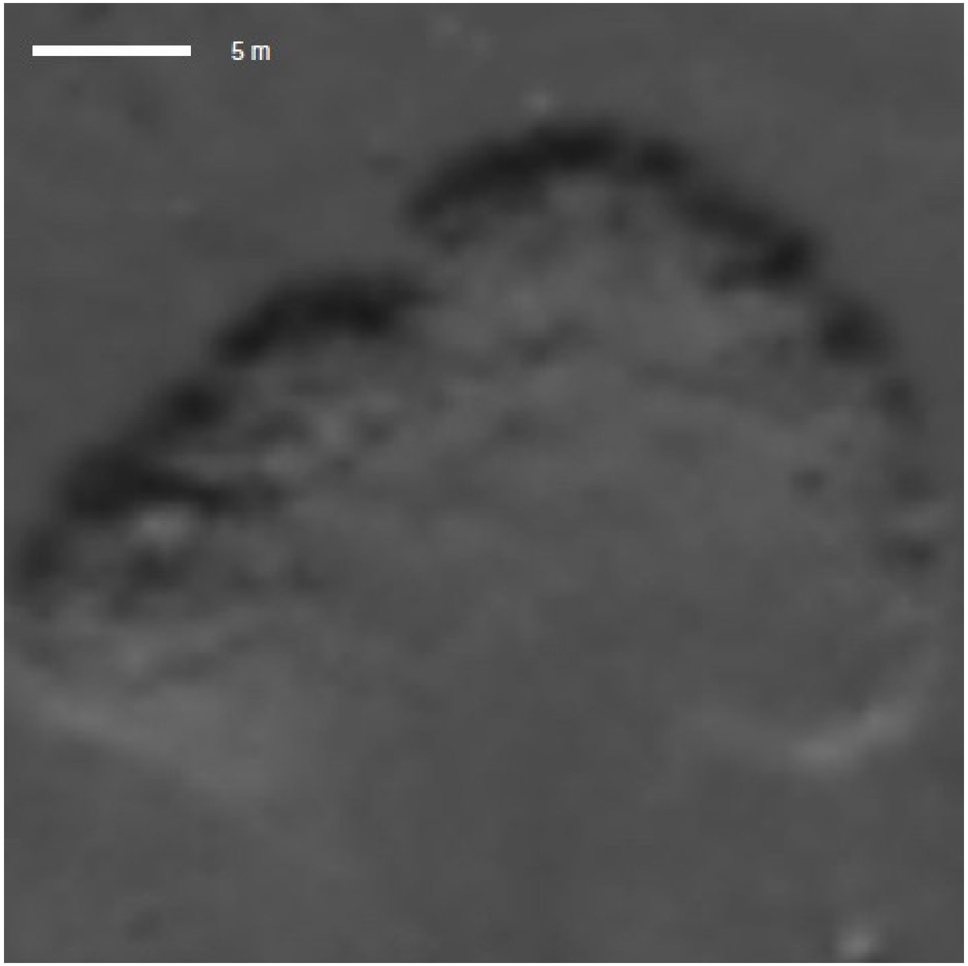
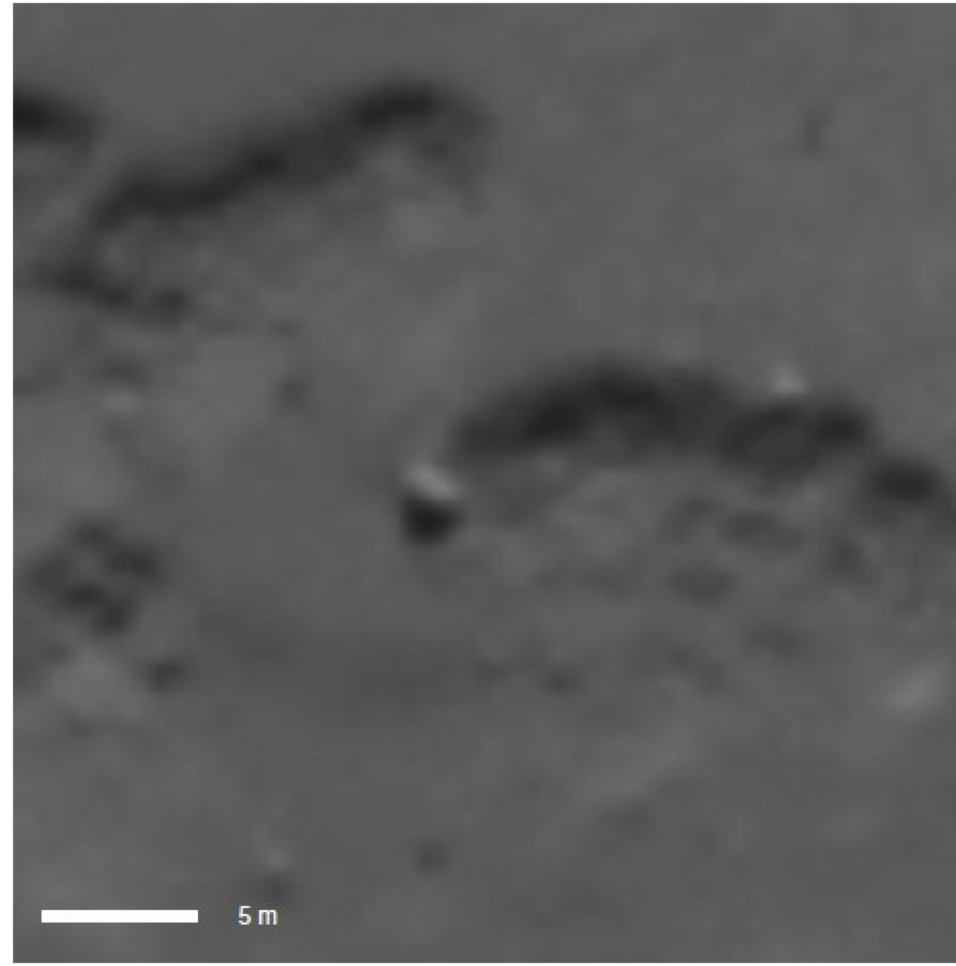


Jan 22, 2015. NAC 27km: 0.49 m px^{-1}.

Credit: ESA/Rosetta/MPS for OSIRIS Team
MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2017, in preparation)

Close-up



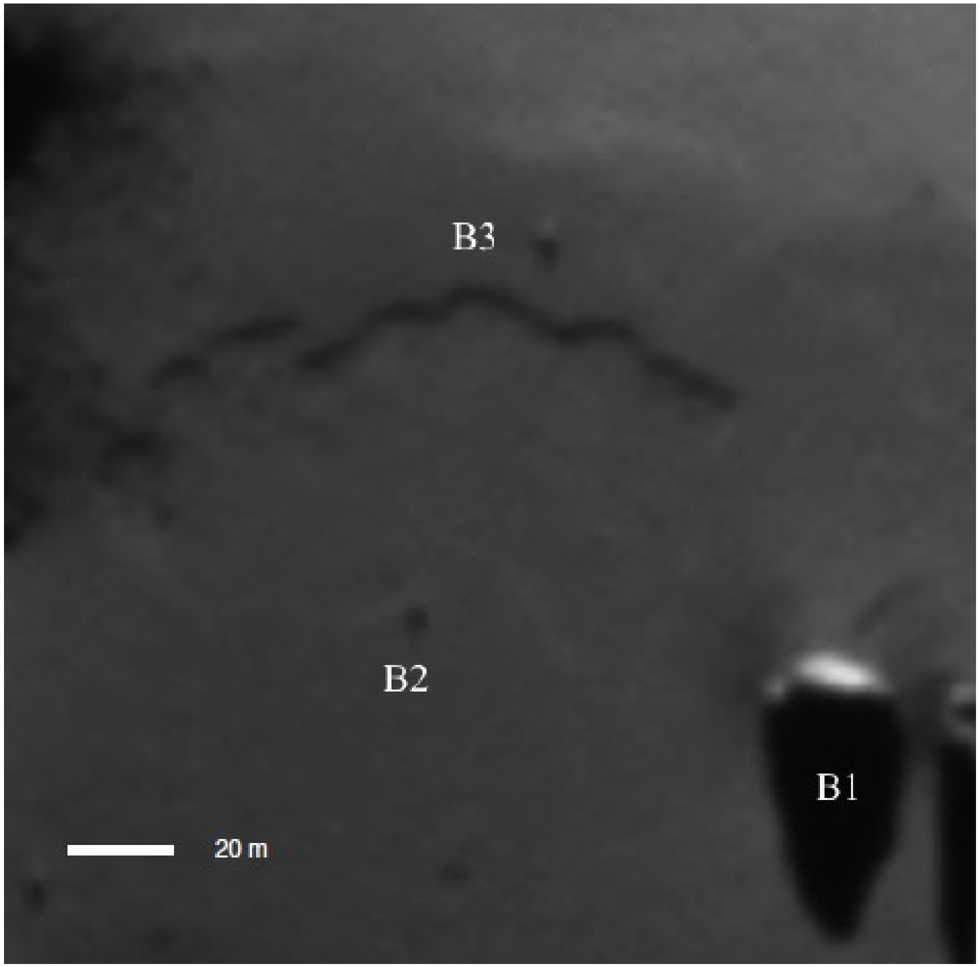


After 11 days: 29 x 20 x 0.5m
Expanded ~ 0.9 m day^{-1}

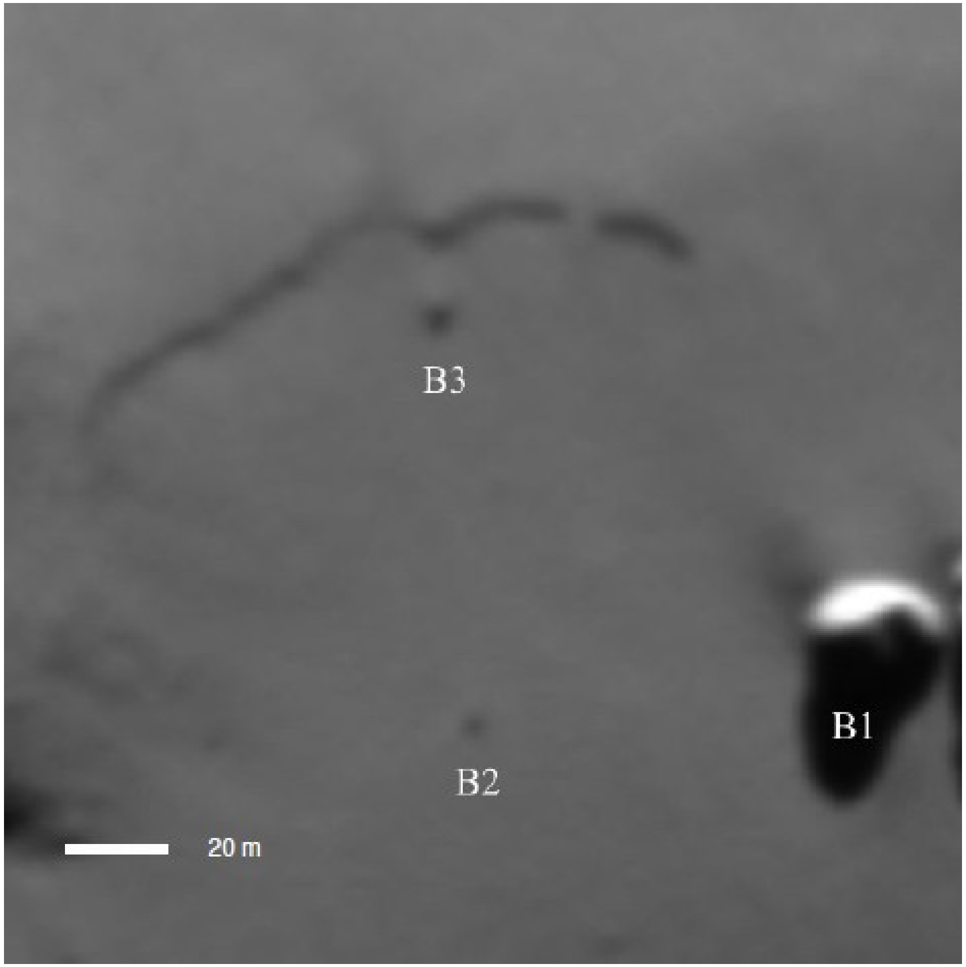
Right half of a 63 x 22 x 0.5m feature
Pit floor irregular and pitted compared to surroundings.

Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2017, in preparation)

A large shallow depression emerges



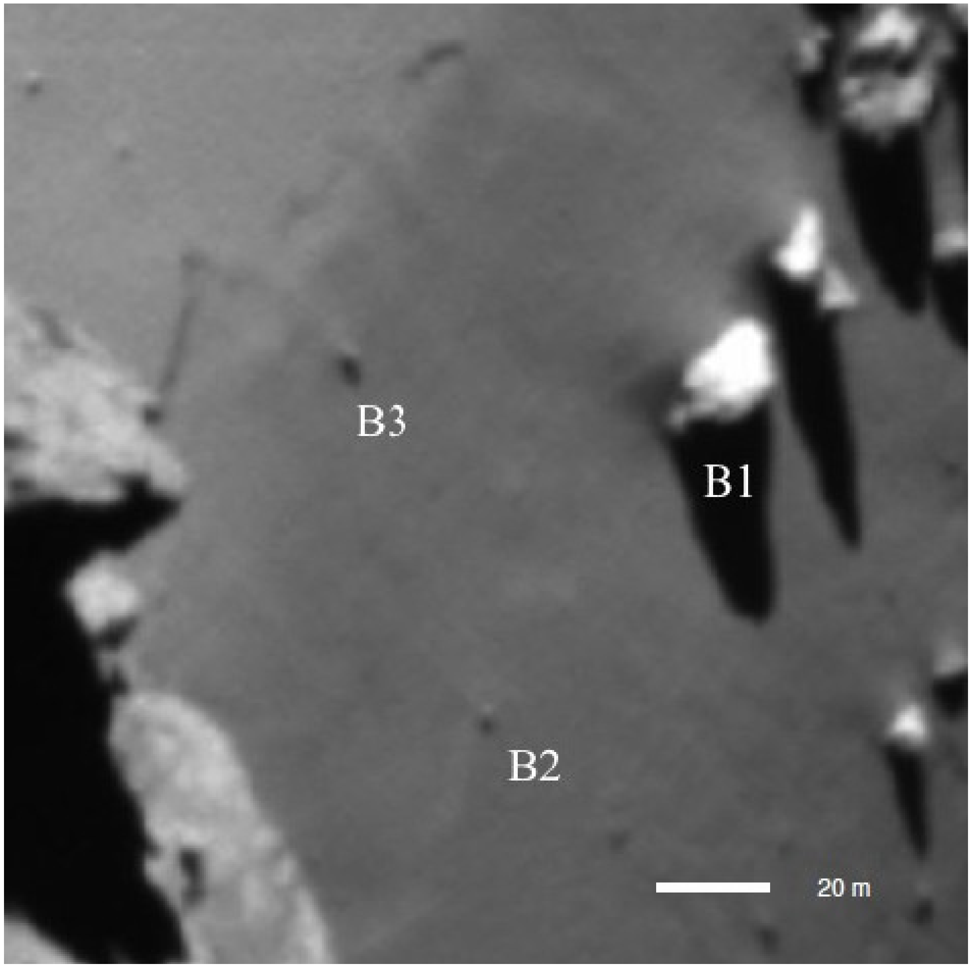
Feb 9, 2015. NAC 106 km: 1.89 m px^{-1}.
Features have merged, moving at 1.7 m day^{-1}



Feb 28, 2015. NAC 108 km: 1.93 m px^{-1}.
Escarpment has passed boulder B3.

Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2017, in preparation)

A large shallow depression emerges



Feature grew to 75 x 110 m in ~ 60 days.

Volume: ~4000 m^3.
Mass: ~2000 metric tons.

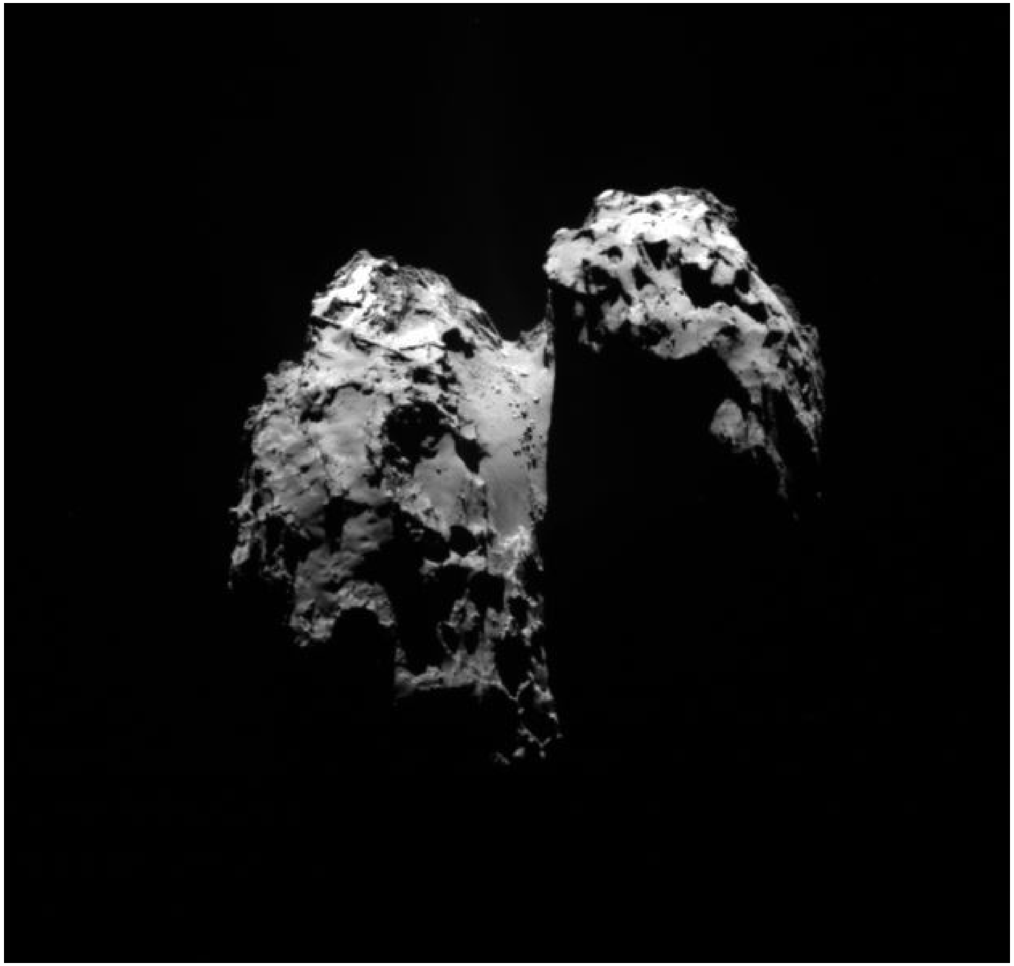
Propagation speed ~ 1 m day^{-1}.

r_h≈2.5 AU in mid Jan:
Sublimation: ~ 0.01 m day^{-1}.

Mar 17, 2015. NAC 77 km: 1.37 m px^{-1}.
Escarpment stops beyond a low ridge.

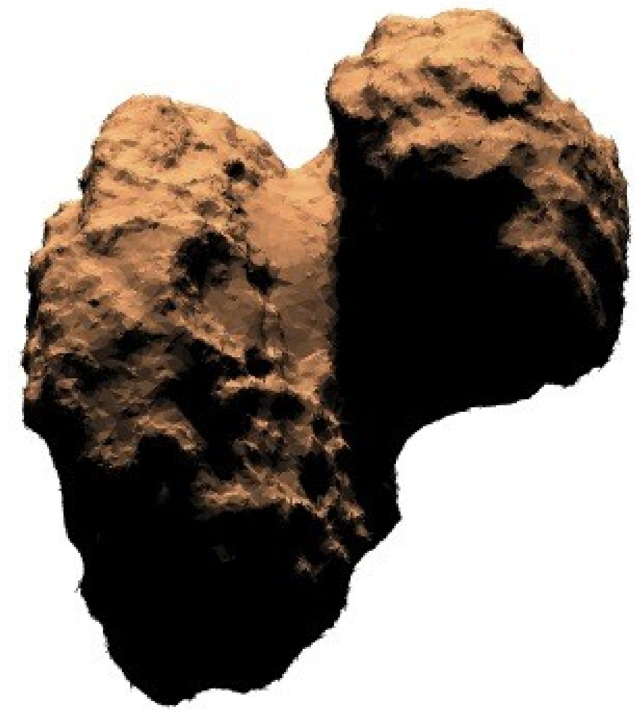
Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2017, in preparation)

Accurate illumination conditions throughout orbit



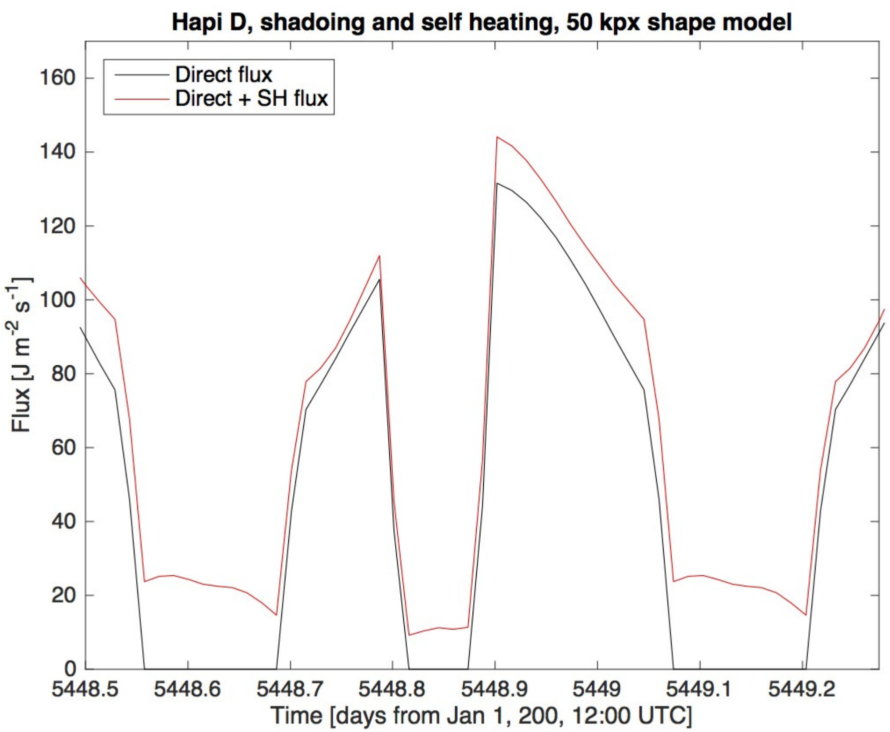
WAC image on Feb 9, 2015,
13:32:56.344 UTC

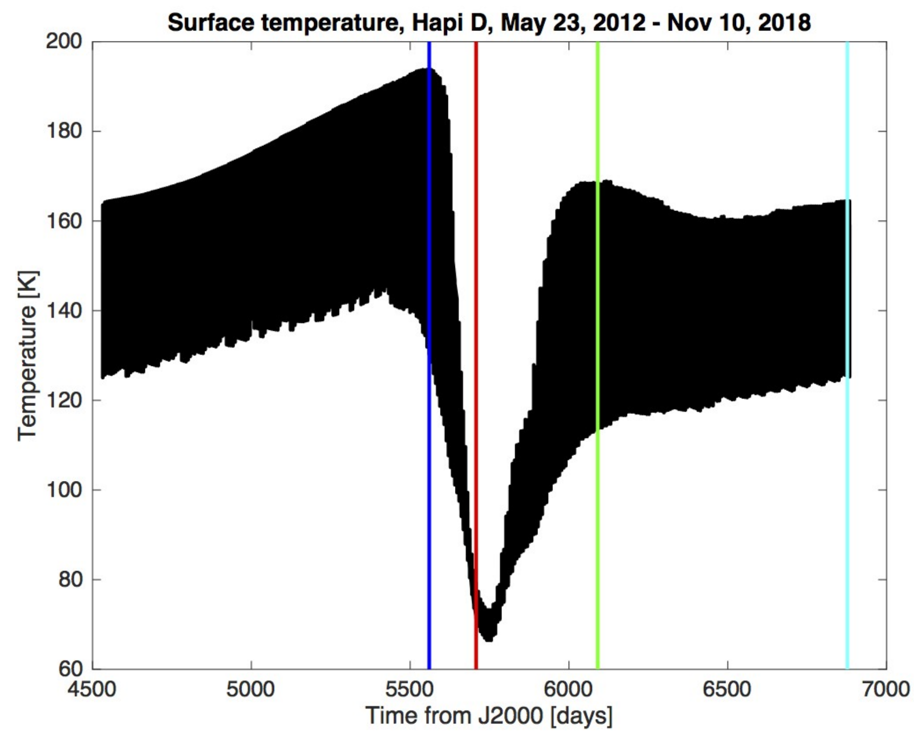
Credit: ESA/Rosetta/MPS for OSIRIS Team
MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA



Synthetic image generated with the model of
Davidsson & Rickman (2014, *Icarus* **243**, 58-77)
Shape model SHAP5 version 1.5 (degraded)
by Jorda *et al.* (2016, *Icarus*, **277**, 257-278)

Accurate illumination conditions throughout orbit





Credit: Davidsson

Shape model with 50,000 facets

Direct solar illumination and shadowing by topography

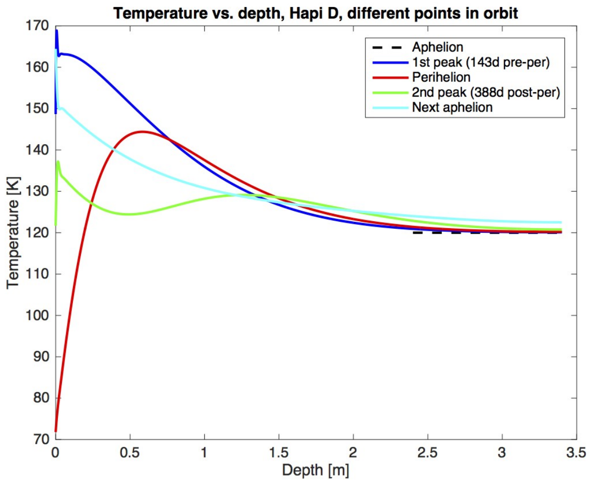
Vis+IR self-illumination from surrounding terrain.

10° rotational steps throughout orbit.

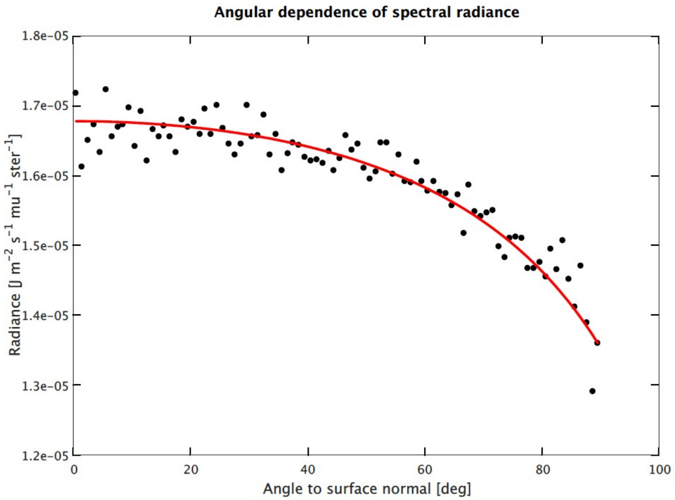
1D heat conduction equation with upper boundary condition balancing illumination, thermal emission, heat conduction, ice sublimation.

Temperature T versus depth x and time t. Start with 90K during 1959 Jupiter encounter, integrate until present.

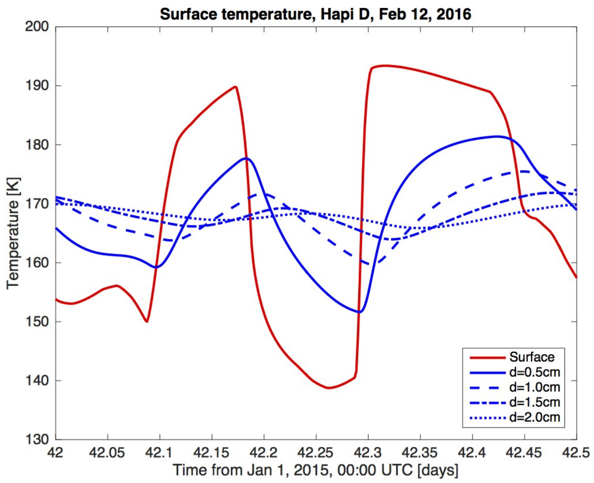
Thermophysics and radiative transfer



Modeling the upper 3.4 meters.
T=T(x) at different times during orbit.



Temperature profile function of
* Ice abundance
* Thermal inertia

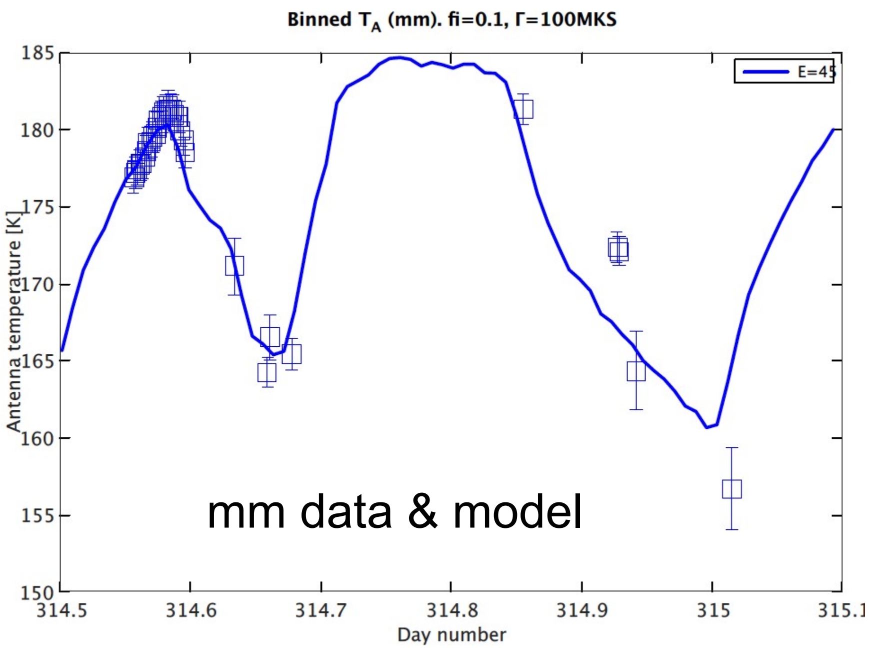


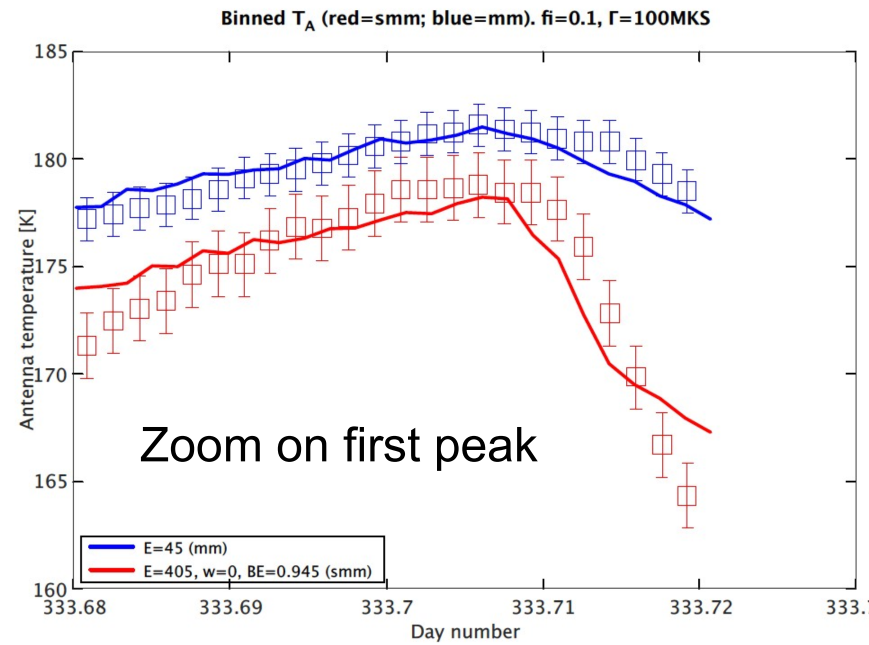
T(t) for different depths for one comet day

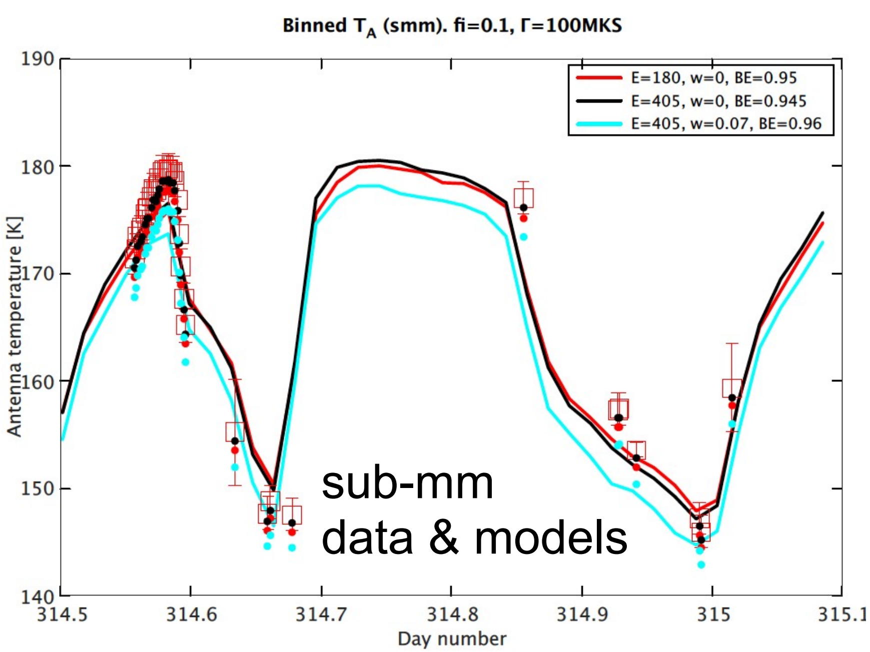
Inserted into radiative transfer solver to calculate mm and smm radiances measured by MIRO, presented as *antenna temperature.*
Function of (per wavelength)
* Extinction coefficient
* Single-scattering albedo

Credit: Davidsson

November 2014 conditions







Most convincing fit thus far:

10% ice, thermal inertia 100 MKS

E_{mm}=45±15 m^{-1} (90% extinction over 5cm)

E_{smm}=405 m^{-1} (90% extinction over 6mm)
w=0.11

Fine grid parameter search in locations where coarse grid yield decent solutions.

Outlook

- Similar data for Oct & Dec 2014: study changes over time
- Comparison with nearby-region that did not display changes at this time
- Complement study with OSIRIS spectrophotometry